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THE EDGE OF THE POLAR PLATEAU FOR GALACTIC COSMIC RAYS AND THEIR CHARGED ALBEDO

by J. A. Van Allen and W. C. Lin

Prepared under Grant No. NsG-233-62 *by*
STATE UNIVERSITY OF IOWA
Iowa City, Iowa
for

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Lin, Venkatesan, and Van Allen [1963] have reported observations on the spatial distribution of the sum of the absolute intensities of primary galactic cosmic rays and of their charged-particle secondaries (albedo) using a shielded Geiger tube in Explorer 7 in the latitude range $\pm$ 50.5°, in the longitude range 170° E to 305° E in the northern hemisphere and 100° E to 170° E in the southern hemisphere, in the altitude range 550 to 1100 km, and over the 16-month period October 1959 to February 1961. Two of their specific results, which are pertinent to the present paper, were as follows:

(1) The counting rate (after subtraction of the contribution of trapped particles) of the detector in both northern and southern hemispheres and within the above specified geographic regions was represented in a simple and coherent manner as a function of a single parameter, the magnetic shell parameter L [McIlwain, 1961].

(2) The counting rate increased monotonically with increasing L and had an accurately constant value for $L > 2.9$.

Thus the "edge of the cosmic ray plateau" was found to be along the contour $L = 2.9$. (Note that the "knee of the latitude curve", as conventionally defined, was at the slightly lower value $L = 2.6$.)

In a recent paper Seward and Kornblum [1963] have reported geographic locations of the edge of the cosmic ray (polar) plateau in both northern and southern hemispheres and over a comprehensive range of longitudes using observations during mid-September 1961 with the short-lived Air Force satellite flight number 31. The orbital inclination of this satellite was 83° and the apogee and perigee altitudes were 410 and 240 km, respectively. The instrument used in this work was a plastic fluor scintillator mounted on a photomultiplier tube and of sufficient size (unspecified) to detect minimum-ionizing, single-charged particles. The detector was an omnidirectional one shielded over most of its solid angle by 0.34 g/cm^2 of aluminum. The measurements made by Seward and Kornblum with this instrument appear to be comparable to ours with the shielded Geiger tube in Explorer 7.

The geographic locations of the edge of polar plateau of cosmic ray intensity as reported by Seward and Kornblum are shown in Figure 1 (northern hemisphere, average altitude 300 km) and Figure 2 (southern hemisphere, average altitude 400 km). The smooth solid curve in Figure 1 is the average position of the edge of the plateau as drawn by them. To this figure we have added three dashed curves representing the loci of constant L at an altitude of 300 km for three values

of L, namely 2.5, 2.9, and 3.5. In Figure 2 are shown the observed points of Seward and Kornblum in the southern hemisphere together with a solid curve which they calculated, using the Finch-Leaton [1957] harmonic representation of the geomagnetic field, to be the conjugate of their northern hemisphere solid curve. We have also added three dashed curves to Figure 2, representing as before contours of L = 2.5, 2.9, and 3.5, respectively, at the proper average altitude, which was 400 km in the southern hemisphere.

It appears that our contour L = 2.9 gives a fit to the observed points which is equally as good as the empirical (solid) curve in the northern hemisphere (Figure 1) and which is decidedly superior to the calculated conjugate (solid) curve in the southern hemisphere (Figure 2).

Having noted this, we then calculated the L values of the end points of the error bars of all of the observed points of Seward and Kornblum and replotted the data as a function of geographic longitude in Figures 3 (a) and 3 (b).

In the northern hemisphere the means of the upper and lower bounds of the error bars are L = 3.21 and 2.74, respectively. The horizontal dot-dash line at L = 2.97 in Figure 3 (a) is the mean of these two values. The three

corresponding values for the southern hemisphere, Figure 3 (b), are 3.08, 2.68, and an overall mean of 2.88, respectively.

The previously published [Lin, Venkatesan, and Van Allen, 1963] value of L = 2.9 (same for both hemispheres) is represented by the horizontal dotted line segments in Figures 3 (a) and 3 (b) with the respective segments spanning the ranges of longitude of the pertinent Explorer 7 observations. It may be noted that Seward and Kornblum defined the edge of the polar plateau "as that point where an extension of the flat constant counting rate in the central polar region intersects the linear rise (on the logarithmic plot) in counting rate leading to the plateau". In private discussion with Dr. Seward we have determined that this procedure was effectively equivalent to our method of finding the value L = 2.9 as the edge of the plateau. We believe that our value of 2.9 is uncertain by less than $\pm$ 0.1. It is difficult to give a satisfactory discussion of errors, even on the basis of Figure 3, but we wish to suggest that the new data of Seward and Kornblum permit the following provisional summary:

(a) The Explorer 7 value of L = 2.9 as representing the edge of both northern and southern polar plateau is confirmed and shown to be applicable to the complete range of longitude in both hemispheres.

(b) A further example of the validity of L as a latitude parameter for particles arriving from infinity has been exhibited and

(c) The position of the edges of the plateau in September 1961 did not differ significantly from the average position during the period October 1959 to February 1961.

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FIGURE CAPTIONS

Figure 1. Observed points are data of Seward and Kornblum [1963] on the position of the edge of the polar plateau of cosmic ray intensity at 300 km altitude in the northern hemisphere in September 1961. The solid curve is their smoothed representation of the observations. The three dashed curves are contours of constant magnetic shell parameter L [McIlwain, 1961] calculated by the authors of the present paper.

Figure 2. A southern hemisphere plot for 400 km altitude, similar to Figure 1, except that the solid curve of Figure 2 was calculated by Seward and Kornblum to be conjugate to the solid curve in Figure 1.

Figure 3. A different presentation of the data of Seward and Kornblum. The mean position of the edge of the polar plateau is found at (a) L = 2.97 in the northern hemisphere and (b) L = 2.88 in the southern hemisphere (shown by the horizontal dot-dash lines in the respective figures). The horizontal dashed line segments represent the corresponding quantity from Explorer 7 data published by Lin, Venkatesan, and Van Allen [1963] (see text), at L = 2.9.

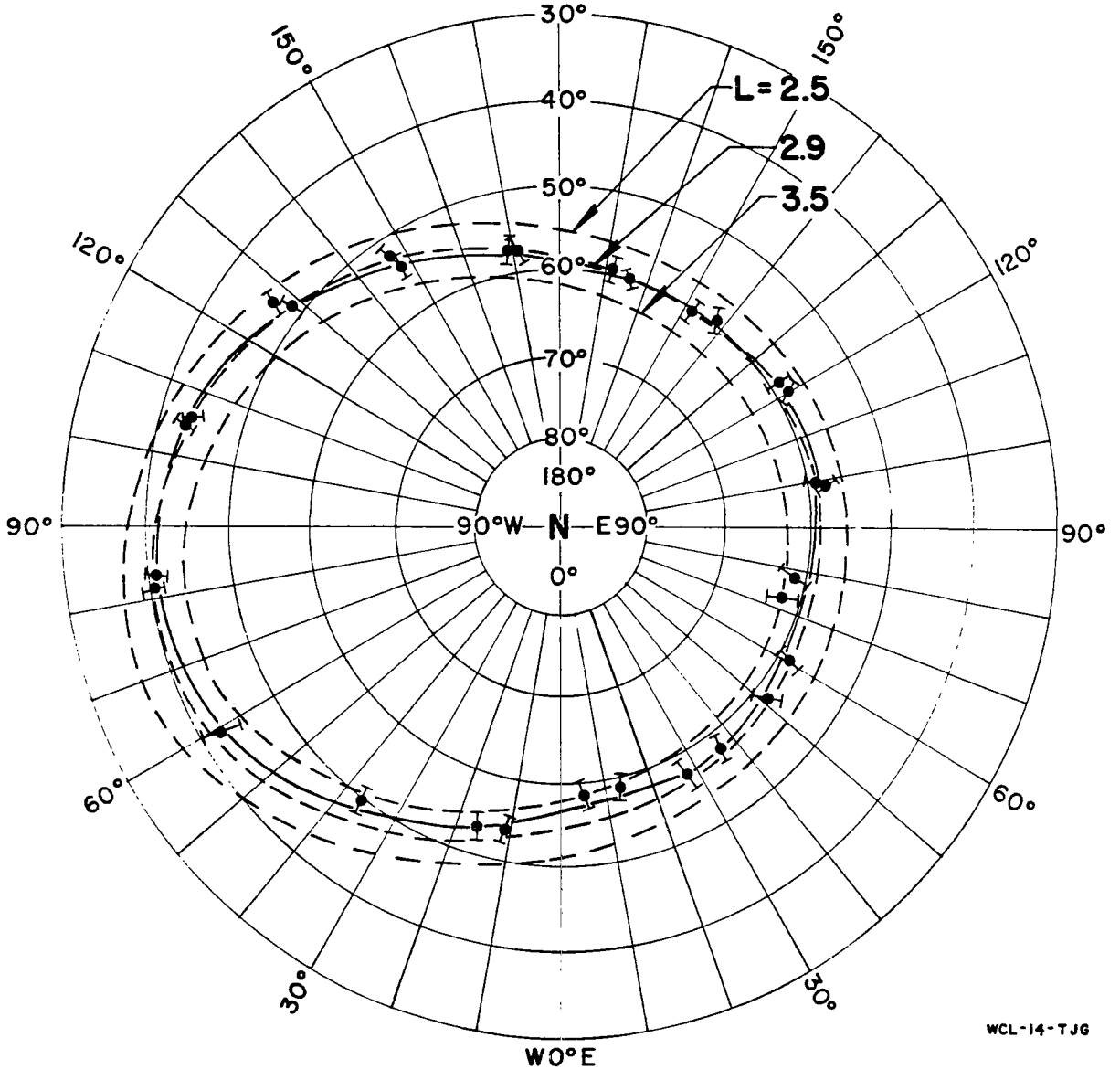
30°
150°
150°
40°
L=2.5
2.9
3.5
50°
120°
120°
60°
70°
80°
180°
90°
90°W
N
E90°
90°
0°
60°
60°
30°
30°
W0°E
WCL-14-TJG

Figure 1

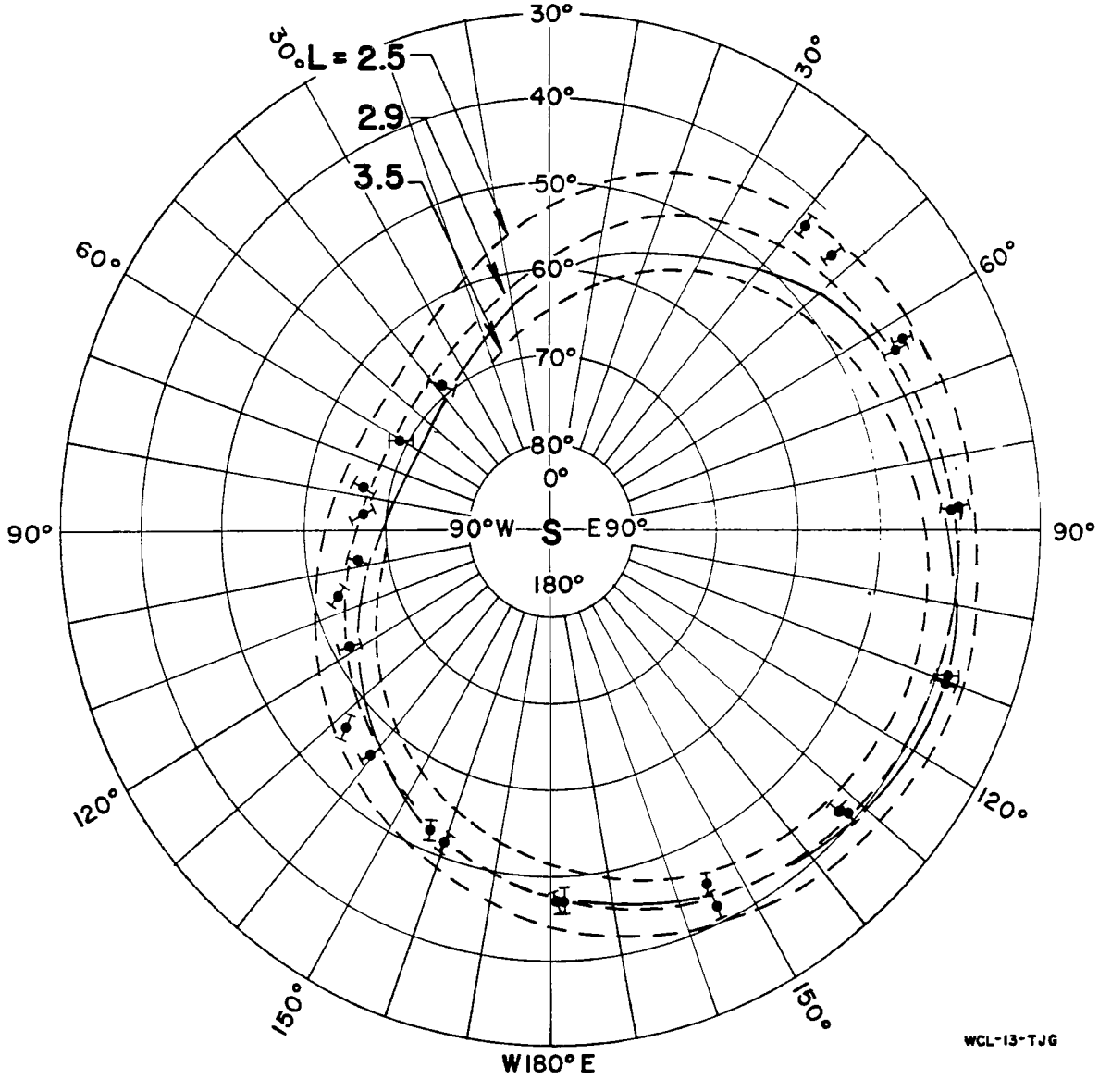
30°
40°
50°
60°
70°
80°
0°
30°
60°
90°
120°
150°
180°
90°W
E90°
S
W180°E
30°L = 2.5
2.9
3.5
WCL-13-TJG

Figure 2

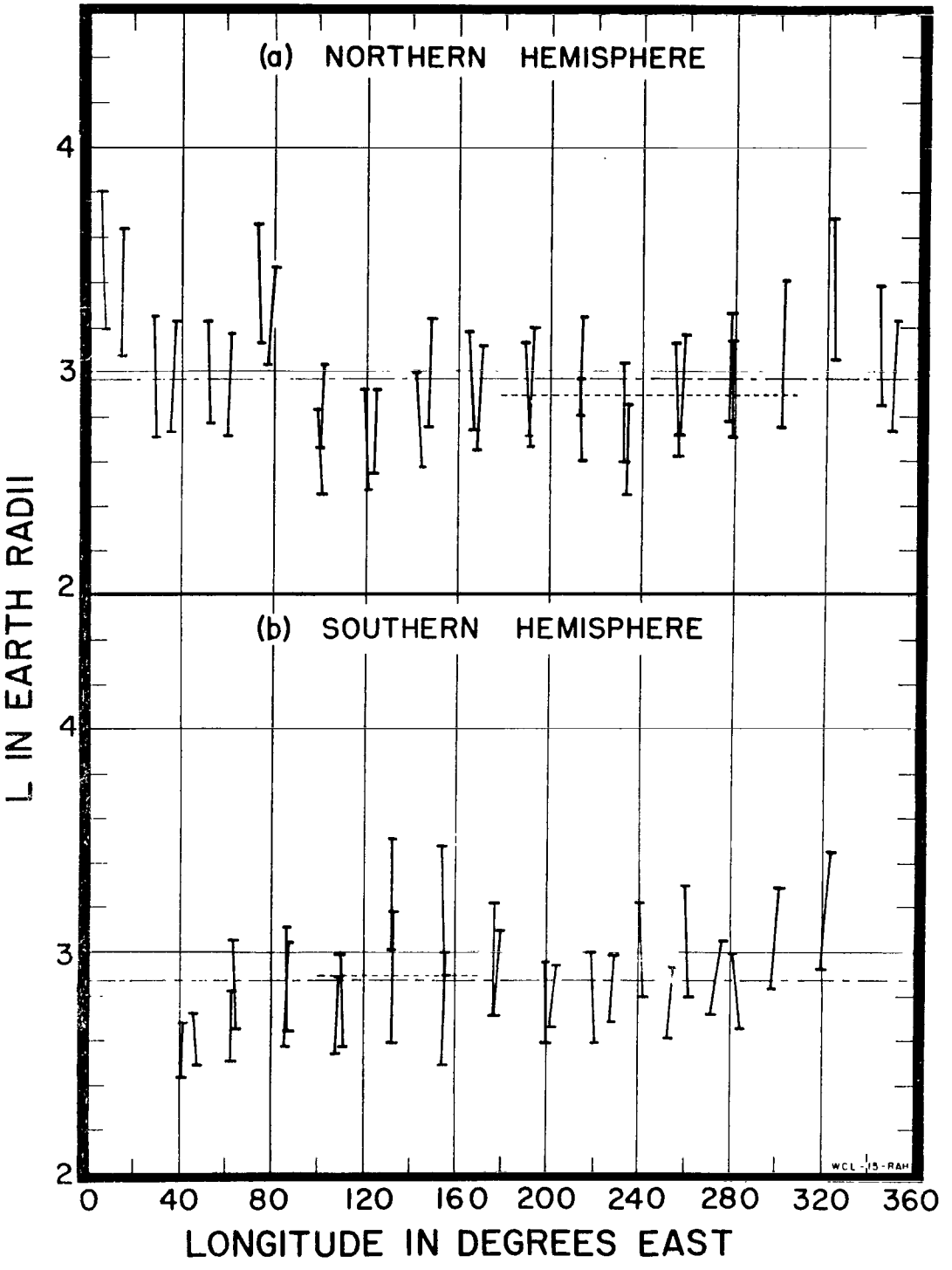

Figure 3

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